Global OSSEs at NCEP

Michiko Masutani

http://www.emc.noaa.gov/research/osse

NCEP

WHERE AMERICA'S CLIMATE AND WEATHER SERVICES BEGIN

Co-Authors and Contributors

Michiko Masutani[1#], John S. Woollen[1 +], Russ Treadon[1],
Stephen J. Lord[1], G. David Emmitt [3], Zoltan Toth[1], John Le Marshal[4]

Thomas J. Kleespies[2] , John C. Derber[1], Haibing Sun[2 %], Sidney A. Wood[3],
Weiyu Yang [1+], Steven Greco[3], Joseph Terry[5], Bert Katz[1 +], Paul VanDelst[1]
Many other people of EMC, NESDIS, and NASA/GSFC

[1]NOAA/NWS/NCEP/EMC, Camp Springs, MD
[2]NOAA/NESDIS, Camp Springs, MD
[3]Simpson Weather Associates, Charlottesville, VA
[4]Joint Center for Satellite Data Assimilation
[5]NASA/GSFC, Greenbelt, MD
[#]RS Information Systems
[+]Science Applications International Corporation
[%]QSS Group, Inc.

OSSEs: Observing Systems Simulation Experiments

Strong Interest in THORPEX

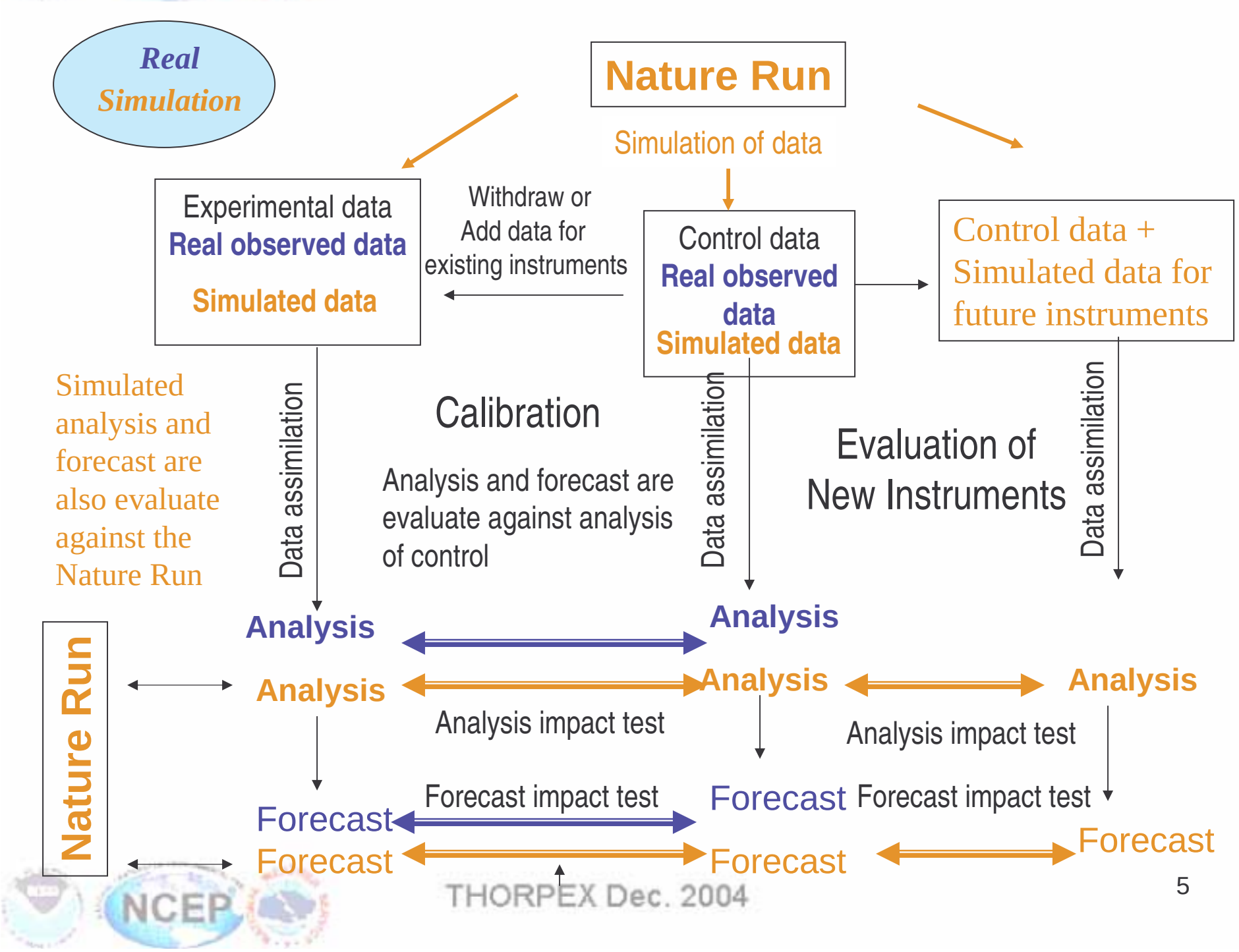
- Quantitatively–based decisions on the design & implementation of future observing systems
- Evaluate possible future instruments without cost of developing, maintaining & using observing systems.
  - *(The cost often exceeds $100 M / instrument)*
- Reducing the significant time lags between instrument deployment and eventual operational NWP use.

Conduct Simulated Observing Systems Experiments (OSSE)

- Requirements definition and instrument design for new instruments
- Test various configurations
- DA system diagnosis and improvement
- Understanding and formulation of observational errors
- Enable data formatting and handling in advance of “live” instrument

Basic Concepts

- **Preparation of the Nature Run**
  - Truth for OSSEs
- **Simulation of observed data**
  - Must contains same kinds of errors as real observations (e.g., representativeness)
  - Be produced by instrument models different from used those in DA system (e.g., radiative transfer model)
- **Calibration**
  - Simulated observations should exhibit similar impact on system as real observations.
    - ***Any difference should be explainable and consistent***
- **Impact test**
  - Analysis impact and forecast impact test


Real Simulation
Nature Run
Simulation of data
Experimental data
Real observed data
Simulated data
Withdraw or
Add data for
existing instruments
Control data
Real observed data
Simulated data
Control data +
Simulated data for
future instruments
Simulated analysis and forecast are also evaluate against the Nature Run
Data assimilation
Calibration
Analysis and forecast are evaluate against analysis of control
Data assimilation
Evaluation of New Instruments
Data assimilation
Nature Run
Analysis
Analysis
Analysis
Analysis
Analysis impact test
Analysis impact test
Forecast impact test
Forecast impact test
Forecast
Forecast
Forecast
Forecast
THORPEX Dec. 2004

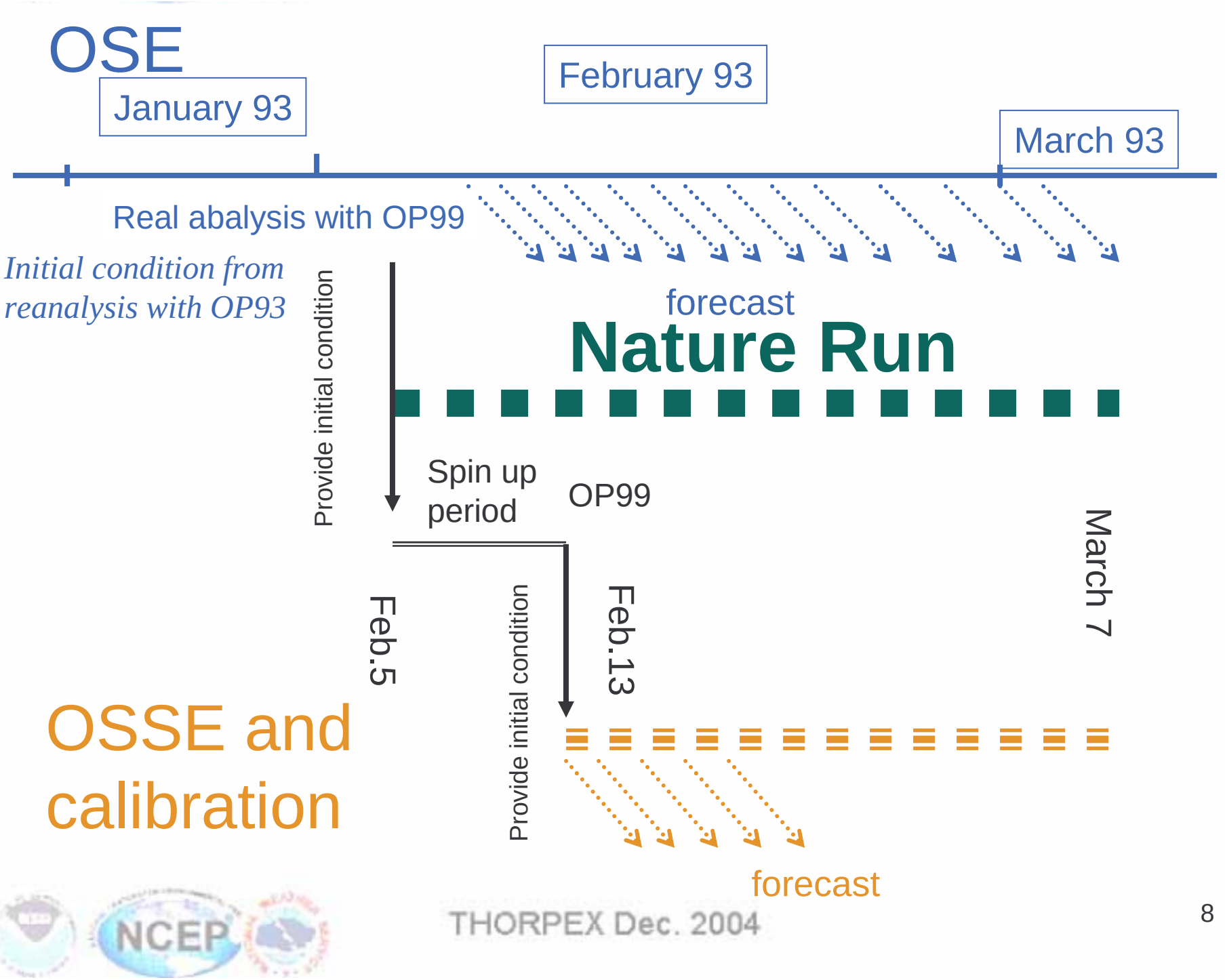
Challenges in OSSE Research

- The concept of OSSE is simple. However, there are many details in achieving a reliable OSSE
  - short cuts will degrade OSSE
  - It is not possible to reproduce the real system perfectly
    - Evaluate the consequences of a shortcut and present with results
- OSSE is a very labor intensive project.
  - Collaboration is very important
- Require many experts in many fields.
  - Involve all elements of NWP
  - Small amounts of time from many people needed
- There are limitations from the nature run provided
  - The limitations need to be evaluated
- Results keep changing as DA system develops
  - OSSEs need to be repeated over and over again with different systems in various NWP centers.

THORPEX is an ideal frame work for collaborative OSSE work.

Characteristics of NCEP OSSE

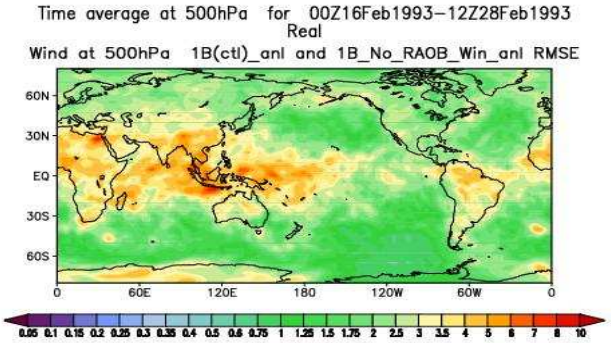
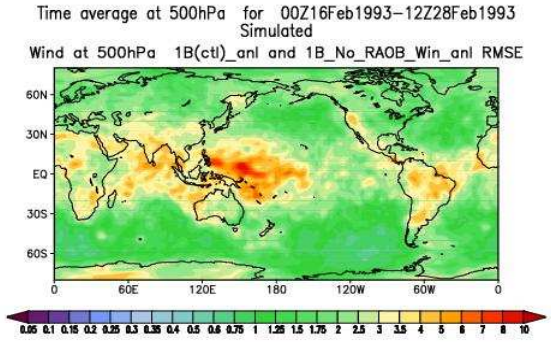
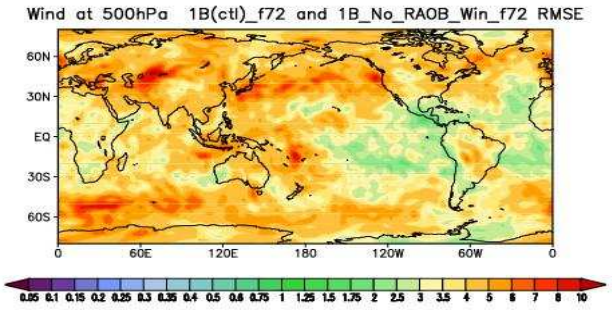
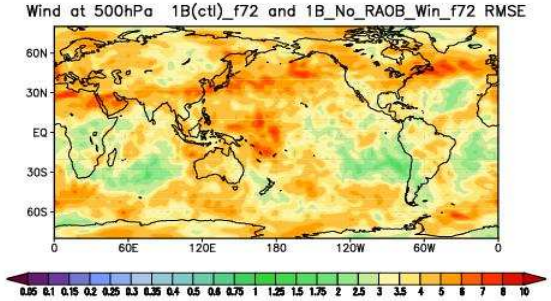
- Winter time Nature run (1 month, Feb5-Mar.7,1993)
- NR by ECMWF model T213 (~0.5 deg)
- NCEP DA withT62 ~ 2.5 deg and
  T170 ~1 deg
- 1993 data distribution for calibration.
- Simulate and assimilate satellite 1B radiance
  - Different method than using interpolated temperature as retrieval
- Use line-of- sight (LOS) wind for DWL
  - not u and v component
- Calibration performed
- Effects of observational error tested
- NR clouds are evaluated and adjusted


OSE
January 93
February 93
March 93
Real abalysis with OP99
Initial condition from reanalysis with OP93
Provide initial condition
forecast
Nature Run
Spin up period
OP99
Feb.5
Provide initial condition
Feb.13
March 7
OSSE and calibration
forecast

OSSE Calibration

- Compare real data sensitivity to sensitivity with simulated data

Impact of withdrawing RAOB winds

Real		Simulated
	Analysis	
	72 hour forecast	

Impact Assessment of a DWL using OSSEs

Bracketing experiments were performed
The real DWL will be somewhere among these.

All levels (Best-DWL): Ultimate DWL that provides full tropospheric LOS soundings, clouds permitting.

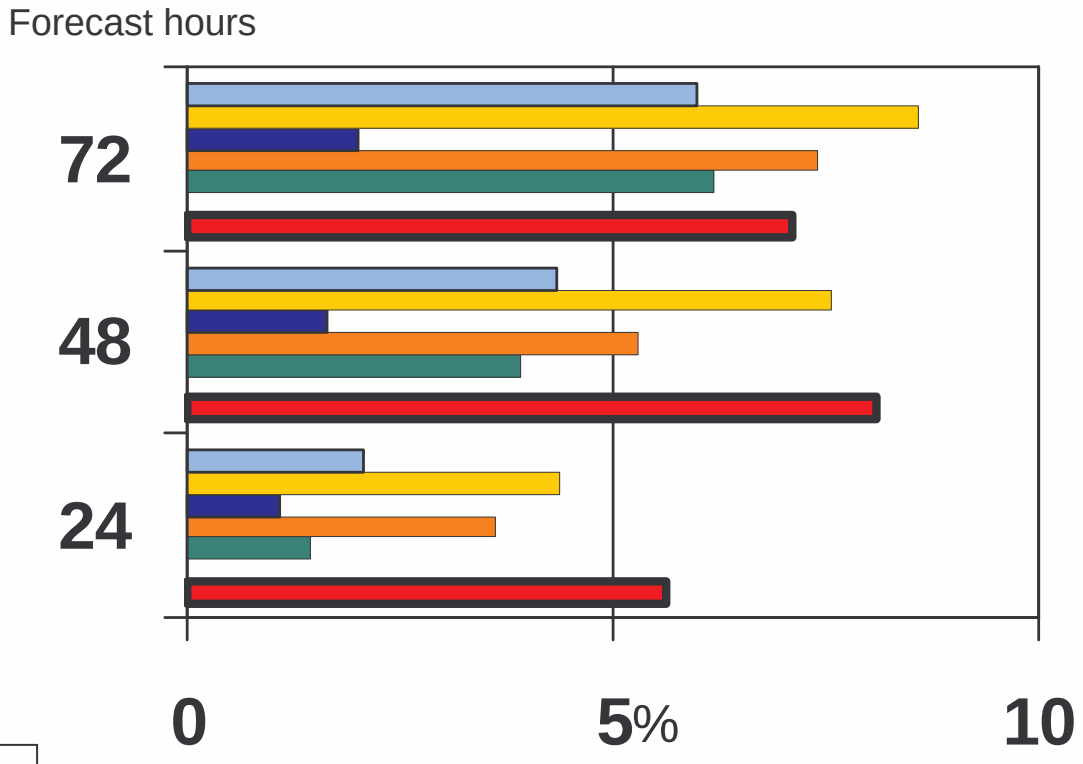
DWL-Upper: An instrument that provides mid and upper tropospheric winds only down to the levels of significant cloud coverage.

DWL-PBL: An instrument that provides only wind observations from clouds and the PBL.

Non-Scan DWL : A non-scanning instrument that provides full tropospheric LOS soundings, clouds permitting, along a single line that parallels the ground track.

Highlight of the Results from DWL OSSEs

- Scanning significantly increases the impact
- In NH, DWL with scanning is required to produce additional skill over existing data
- Non-scan DWL may produce significant impacts in NH with radiance data



The diagram is anomaly correlations with nature run for 200mb V. Improvement in forecast skill with respect to forecasts with RAOB and surface data only. Skill for Northern Hemisphere synoptic scale events are presented. The resolution of DA is T62.

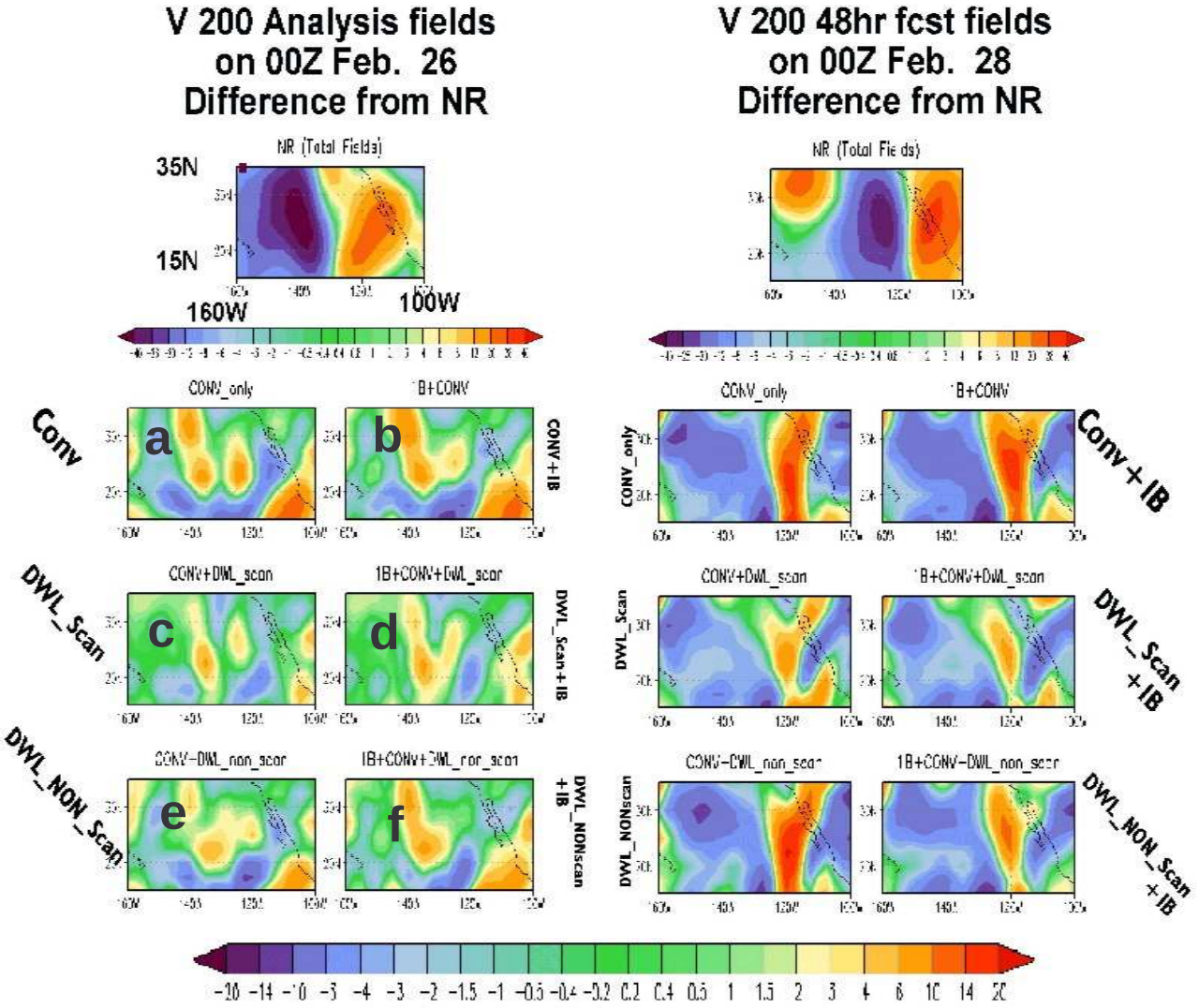
Impact of DWL in Synoptic event (Note)

Data impact on analysis at 00Z February 26, 1993 and their 48 hour forecasts at 00Z February 28 in 200 hPa meridional wind fields.

Two figures on top show total fields of NR. Analysis and forecasts are presented as difference from NR.
Green indicate smaller differences from NR.

Analysis with
(a) Conventional data only,
(b) Conventional data + TOVS 1B
(c) Conventional data+Best DWL
(d)Conventional data + TOVS 1B + Best DWL
(e) Conventional data+non-scan DWL
(f)Conventional data + TOVS 1B + non-scan DWL

Impact of DWL in Synoptic event

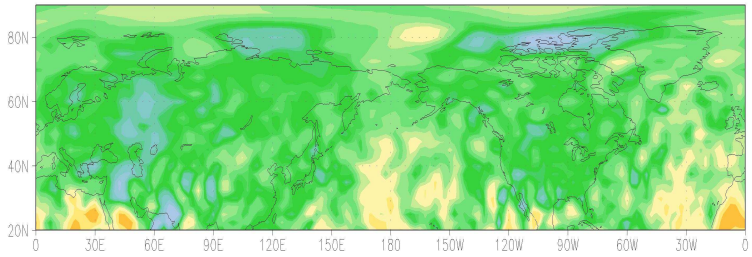


Other finding through DWL OSSEs

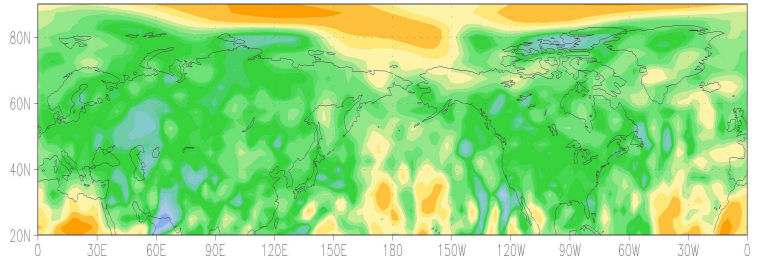
- Upper level data become more important after 3 days even at lower levels
- Impact of DWL is more significant at smaller scales
- In tropics large analysis impacts diminish rapidly
  - Need more model improvement to achieve forecast impact
  - DWL will be useful in evaluating analysis
- Systematic large scale error added to the simulated data increase the data impact at large scale
- There are evidence that even non-scan lidar will produce an almost similar amount of impact as RAOB wind in NH average.
  - RAOB wind has more impact over land. Non-scan lidar has more impact over ocean and tropics.
- In SH, a non-scan DWL can produce comparable impacts with 1993 TOVS
- Scanning is more important in upper troposphere than in lower troposphere

Impact of DWL with Scanning
T170 vs. T62

T170

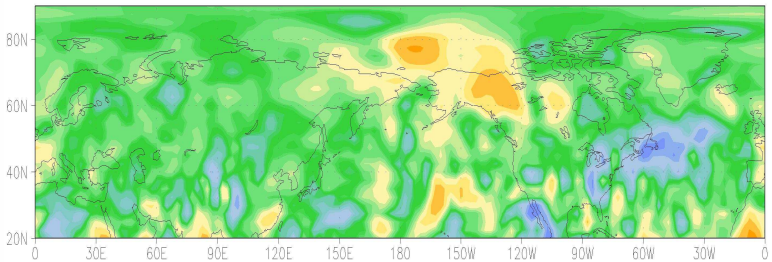


T62

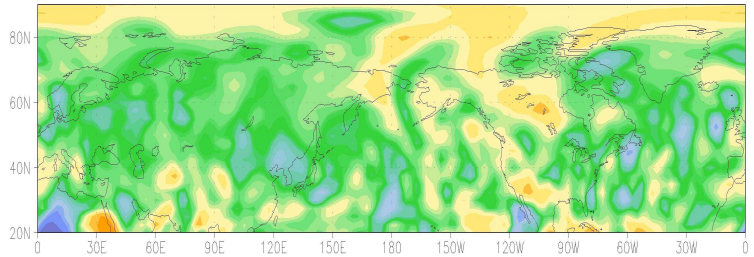


Analysis

T170



T62

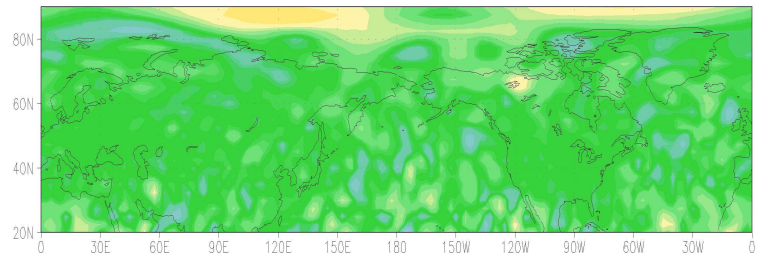


48 hr

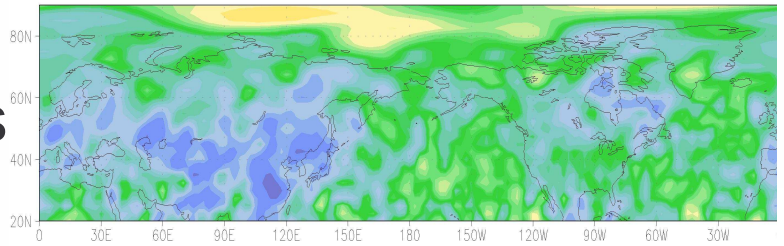
Non-Scan Lidar vs. RAOB Wind
T62 (Feb13-20)

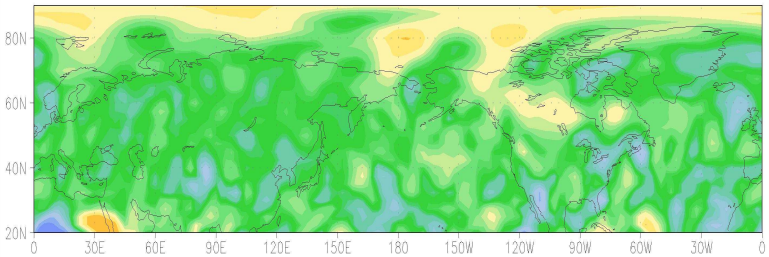
Non-scan Lidar over CTL

Non-scan Lidar vs. RAOB Wind



Analysis





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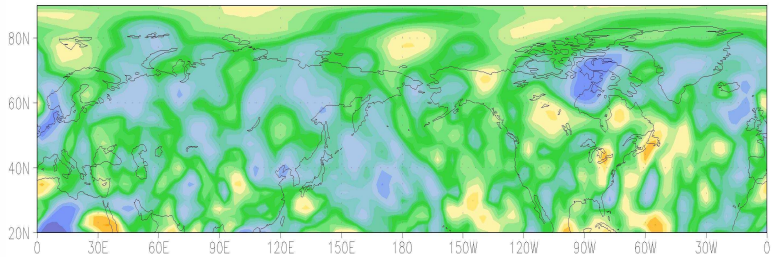
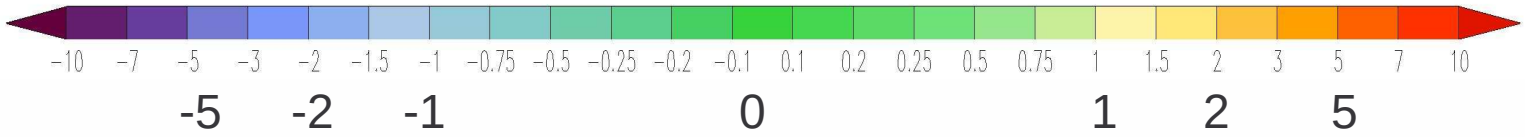




Red: DWL has more impact

Blue: RAOB Wind has more impact

CTL: Conventional Data
no Satellite data

Non-Scan Lidar vs. RAOB Wind
T170 (Feb13- Feb20)

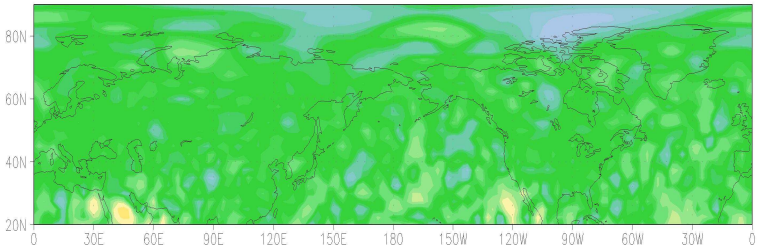
Non-scan Lidar over CTL

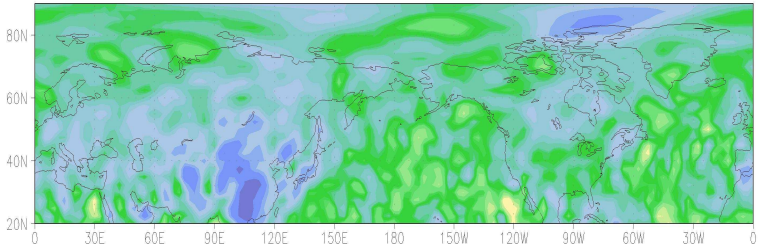
CTL: Conventional Data no Satellite data

Non-scan Lidar vs. RAOB Wind

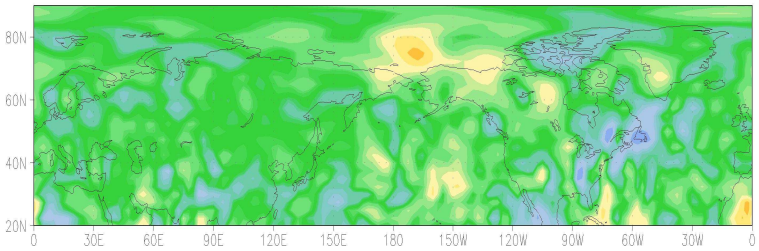
lds

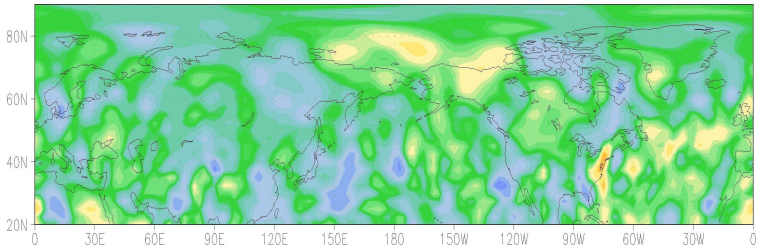
Analysis





48 hr





-5 -2 -1 0 1 2 5

Red: DWL has positive impact
Blue: DWL has negative impact

Red: DWL has more impact
Blue: RAOB Wind has more impact

Non scan DWL vs. RAOB Wind

T62 CTL (reference)
(Conventional data only)

T62 No RAOB Wind-CTL

T62 No RAOB With non scan DWL - CTL

T170 CTL
(Conventional data only) - CTL

T170 No RAOB Wind - CTL

T170 No RAOB With non scan DWL - CTL

◊ CTL
(No RAOB Wind + Raob Wind)

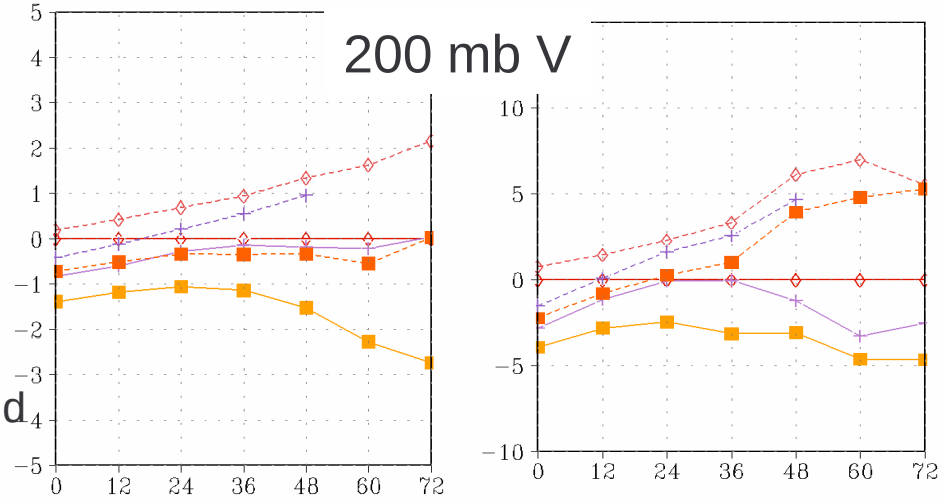
■ No RAOB Wind

\+ No RAOB + non scan DWL

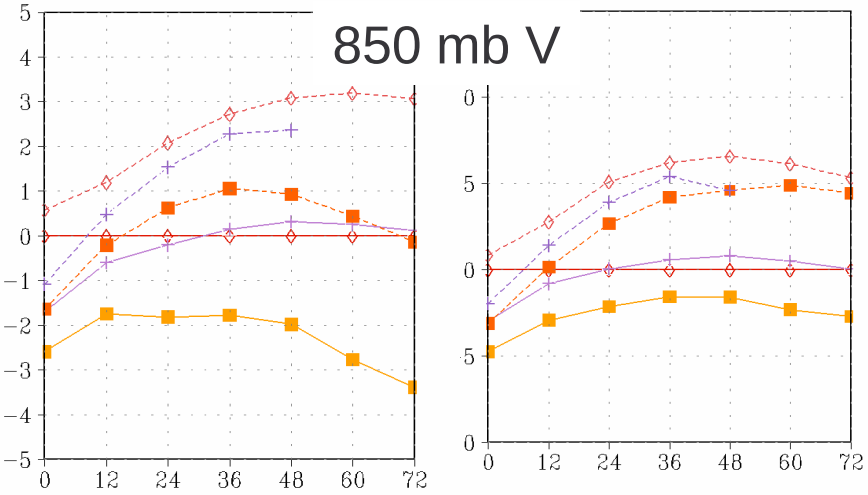
Differences in anomaly correlation

Total scale Synoptic Scale

200 mb V



850 mb V



Data Impact in T62 vs. T170

Differences in anomaly correlation

T62 and T170 CTL
(Conventional data only)

T62 CTLwith Non Scan DWL -T62 CTL

T62 CTL with Scan DWL -T62 CTL

T170 CTL with Non Scan DWL -T170 CTL

T170 CTL with Scan DWL -T170 CTL

◊ CTL

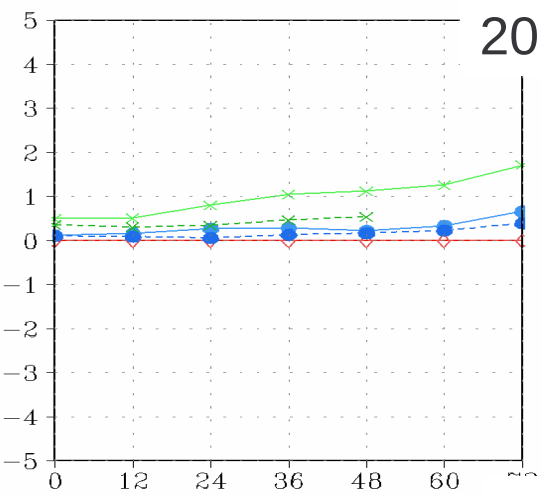
● Non-Scan DWL

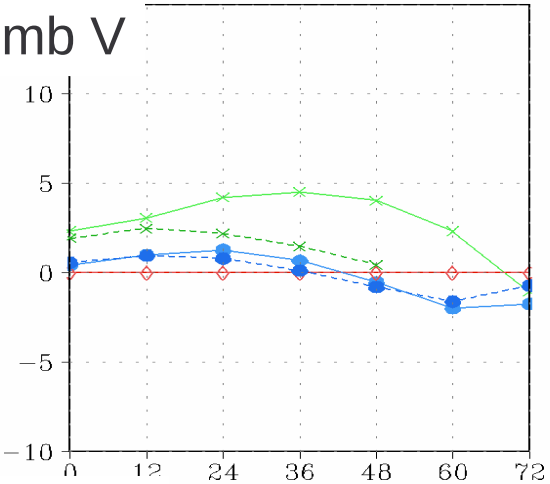
X Scan DWL

Total scale

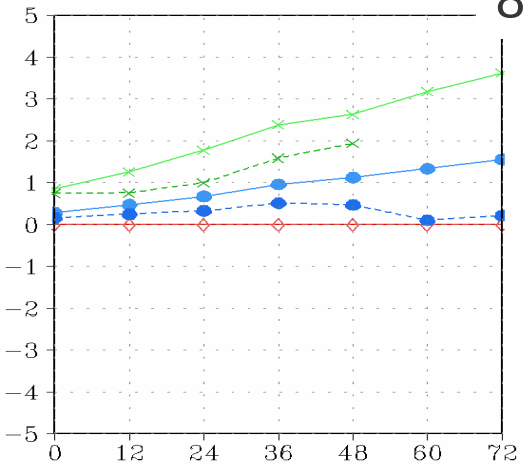
Synoptic Scale

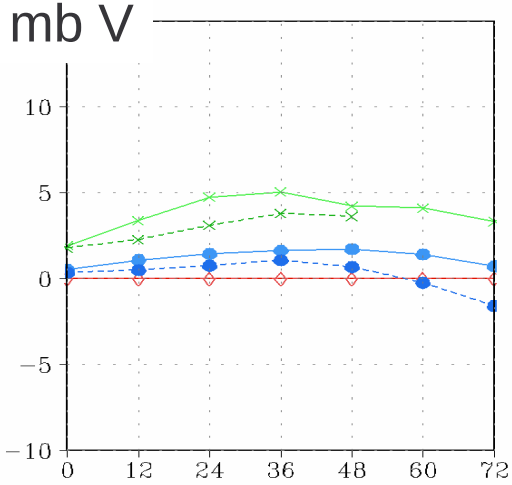
200 mb V





850 mb V





Data Impact of scan DWL vs. T170

Differences in anomaly correlation

NH extrop w

T62 CTL (refernece)
(Conventional data only)

T62 CTL with Scan DWL - T62 CTL

T170 CTL - T62 CTL

T170 CTL with Scan DWL - T62 CTL

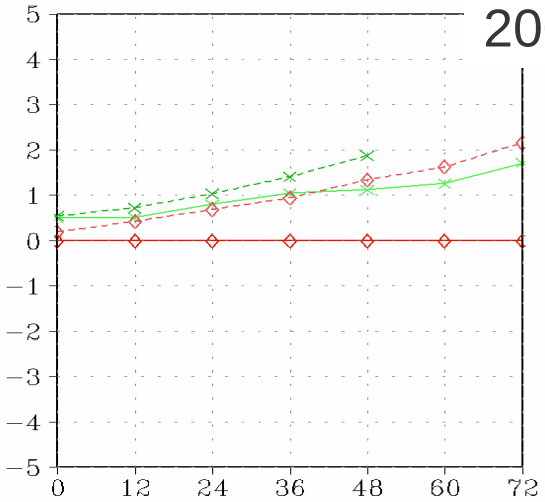
◊ CTL

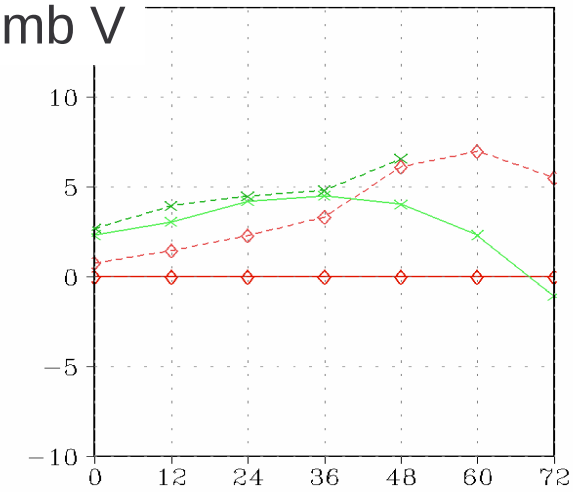
X CTL+Scan DWL

Total scale

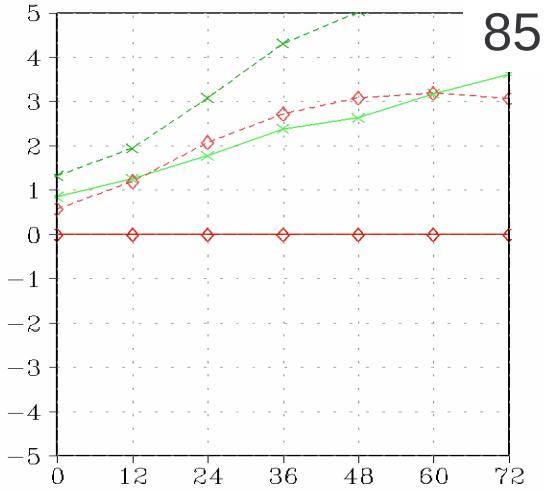
Synoptic Scale

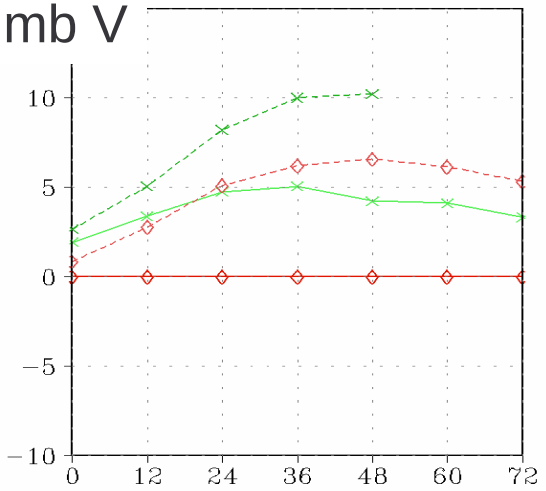
200 mb V





850 mb V





New Nature Run (Sample proposal)

Low resolution Nature Run (L-NR)

- One year (13month) low resolution (~50km) with more vertical levels in stratosphere.
- Remove the drift. (Discard the first month)
- Daily SST(Provided by NCEP)

Select two or three most interesting periods

Get initial condition from L-NR

High horizontal resolution NR

Regional NR with high temporal and high horizontal resolution

High temporal resolution NR

Need more discussion and consider various interests.

The Role of JCSDA in OSSEs

Joint Center for Satellite Data Assimilation (JCSDA) Mission
Accelerate and improve the quantitative use of research and operational satellite data in weather and climate analysis and prediction models

- As a result **a key program element** for the Center is the conduct of OSSEs for advanced satellite sensors to be used for weather and climate (environmental) analysis and prediction.
- Instruments being currently assessed for such experiments are the CrIS, ATMS, GOES-R/GIFTS and the HyMS* – P and G%.

* HyMS Hyperspectral Microwave Sounder

% P- Polar, G Geostationary

Summary

- OSSE is critical tool for THORPEX for:
  - Designing future observing systems
  - Improving DA and ensemble systems
- Current NCEP system showed OSSEs are capable to provide critical information for assessing observational data impact
- Future developments at NCEP will be coordinated with THORPEX program with links to JCSDA
- Need new nature run which will be used by many OSSEs.

Extended collaboration within TORPEX community is essential for timely and reliable OSSEs

- Operational Test Center OTC – Joint THORPEX/JCSDA
- JCSDA (NCEP, NESDIS,NASA), ESA, EUMETSAT